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Yukon River Salmon Studies

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ABSTRACT

The 1980 Yukon area commercial harvest of 1,519,900 salmon was the largest in history and exceeded the previous 5-year average by 407,400 fish. Composition of the 1980 catch was 1,062,500 summer chum, 295,800 fall chum, 152,900 king, and 8,700 coho salmon. Commercial fishermen earned approximately $6,110,000 for their catches. The subsistence harvest of 507,937 salmon was 1-1/2 times greater than the previous 5-year average of 340,500 fish. Composition of the 1980 subsistence catch was 42,724 king and 465,213 other salmon, mostly chum.

The 1980 Anvik River chum salmon escapement was estimated at 482,181 based on sonar counts. This is 18% greater than the previous 5-year average of 409,256 fish. The king salmon escapement was estimated at 1,330 fish by aerial survey. Chum and king salmon carcasses were sampled for age determination.

The Tanana River fall chum salmon run was estimated at 383,770 (± 24,084) based on the recapture of tagged fish. The harvest exploitation rate (commercial and subsistence) was estimated at 17%. The population estimate was 72% greater than the sum of documented catch and observed escapement, and is probably inflated by failure of fishermen to return tags. Due to the inability to capture a sufficient number of chums on the south bank of the Tanana River near Manley Hot Springs, it was not possible to test for a difference in bank orientation between upper Tanana and Toklat River stocks. Based on the weak separation measured in 1979, and the inability to capture fish in 1980, it does not appear that the upper Tanana and Toklat River fall chum salmon stocks can be distinguished by bank orientation in the lower Tanana River near Manley Hot Springs. Examination of run timing indicates that the upper Tanana River stock has an early component that is not seen in the Toklat stock. However, there is great overlap in run timing between the two stocks, and it does not appear that fishing periods could be regulated to allow for single stock harvest in the Manley Hot Springs area.

Tag returns and spawning ground surveys indicated that the great majority of Tanana River coho salmon spawn in the upper Tanana drainage as opposed to the Toklat River.

Both chum and coho salmon were sampled from the fishwheels near Manley Hot Springs for age determination, while chum salmon carcasses were sampled from the Toklat and Delta River spawning grounds. Many of the scales were resorbed and worn away at the edges, and it is advised that otoliths be collected in conjunction with scale sampling in the upper Yukon River drainage in the future.

INTRODUCTION

The Yukon River (Figure 1) is the largest river in Alaska, and fourth largest in North America, flowing over 2,300 mi from its source in British Columbia, Canada, to its mouth on the Bering Sea. It drains an area of approximately 330,000 square mi. All five species of Pacific salmon are found in the drainage, with chum salmon *(Oncorhynchus keta)* being the most abundant. King salmon *(O. tshawystcha)* are second in abundance, followed by coho *(O. kisutch)*, pink *(O. gorbuscha)*, and sockeye *(O. nerka)* salmon. The latter two species are only found in token numbers in the lower portion of the river and are caught occasionally with the more abundant commercial species. The Yukon River is the largest king and chum salmon producing system in Alaska.

Chum salmon occur in two distinct runs in the Yukon River drainage. Fall chum salmon can be distinguished from summer chum salmon by their later run timing (mid-July to late August), larger body size (7 to 9 lb), and bright silvery appearance. Fall chum salmon spawn in the upper portion of the drainage in spring fed streams and sloughs. Major spawning areas include the Chandalar, Sheenjek, and Fishing Branch Rivers in the Porcupine drainage, and the Toklat, Delta, and main Tanana River in the Tanana drainage. Summer chum salmon spawn primarily in runoff streams in the lower 500 mi of the drainage. Major spawning areas include the Andreafsky, Anvik, and Nulato Rivers.

The objective of the Yukon area salmon management program is to manage the various stocks for optimum sustained yield. The commercial fishery is regulated on the assumption that a harvestable surplus is available after subsistence needs and spawning escapement requirements are met. The research staff contributes to the accomplishment of management objectives by monitoring escapements in the major tributaries and identifying discrete stocks by tagging and scale pattern analysis.

This report emphasizes data collected during the 1980 field season with comparisons to the existing data base where appropriate. The major projects discussed are the Anvik River salmon escapement study and the Tanana River fall chum and coho salmon tagging study. In addition, commercial and subsistence catch data, lower river test fishing, and aerial survey escapement information is briefly summarized. Results from studies conducted earlier in the completion report period are presented in detail in annual technical reports (Mauney 1979; Mauney 1980; Mauney and Buklis 1980).

SUPPORT STUDIES

Catch Data Analysis

Yukon River commercial fishery catch statistics (including date, location, and numbers of fish) are recorded on fish tickets when the fish are purchased from the fishermen. The tickets are collected from the buyers and processors

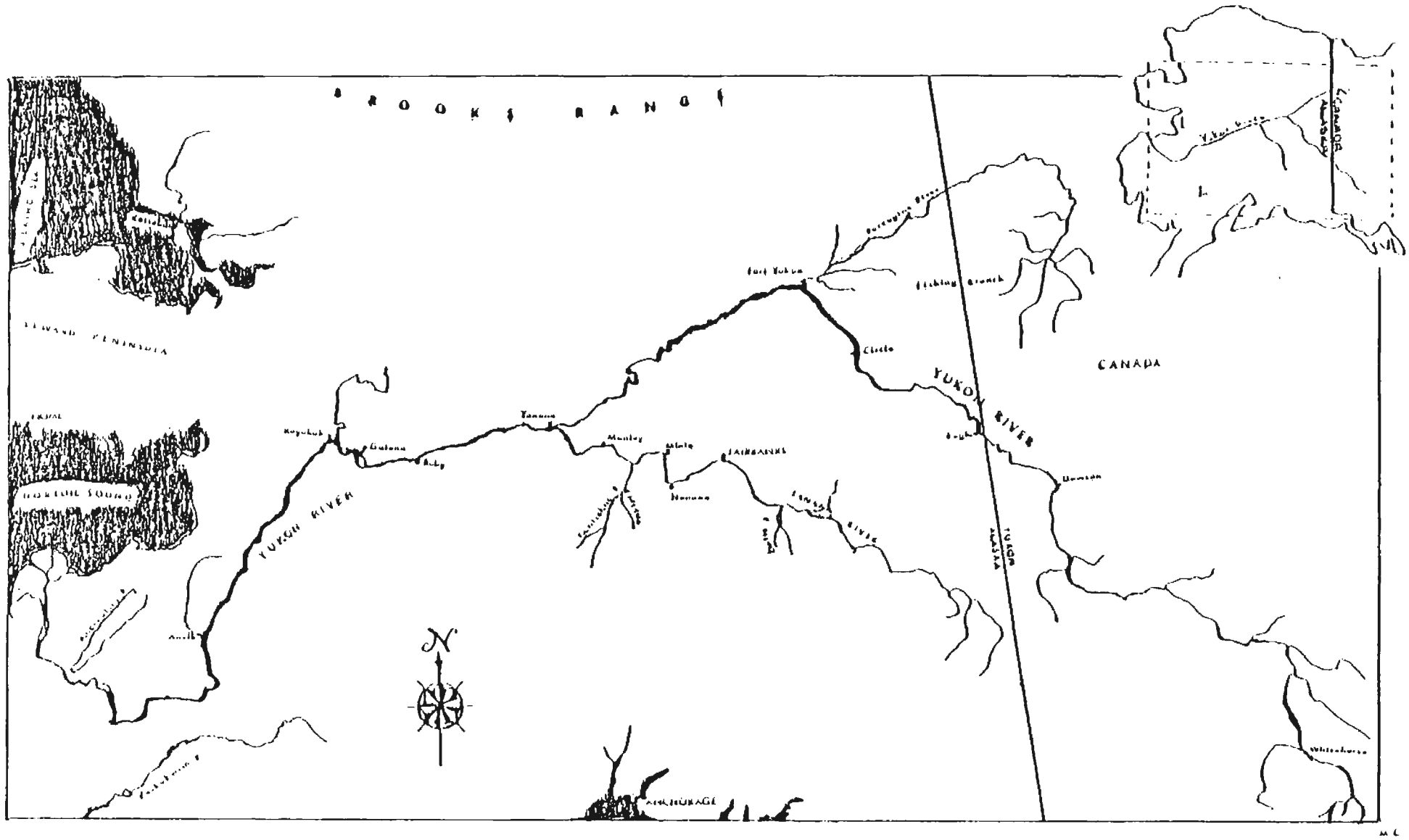

Figure 1. Map of the Yukon River.

by Alaska Department of Fish and Game personnel after each fishing period. Catch and effort data are compiled from these records.

Department personnel conduct a subsistence survey by boat and aircraft at the conclusion of the season. Fishermen in most villages are interviewed to obtain an estimate of the number of each species of salmon taken and related effort data. Catch calendars are mailed to the fishermen prior to the season to facilitate record keeping. The few fishermen not interviewed are sent questionnaires.

The 1980 Yukon area (Alaska portion of the drainage) commercial harvest of 1,519,900 salmon was the largest in history and exceeded the previous 5-year average by 407,400 fish. Composition of the 1980 catch was 1,062,500 summer chum, 295,800 fall chum, 152,900 king, and 8,700 coho salmon. Commercial fishermen earned approximately $6,110,000 for their catches. The subsistence harvest of 507,937 salmon was 1-1/2 times greater than the previous 5-year average of 340,500 fish. Composition of the 1980 subsistence catch was 42,724 king and 465,213 other salmon, mostly chum, but including coho and pink salmon.

Lower Yukon River Test Fishing

Test fishing has been conducted on the lower Yukon River since 1963 to determine the relative run strength and timing of the various salmon stocks as they enter the fishery. Test fishing operations were moved 24 mi upriver in 1979, from Flat Island to the Big Eddy and Middle Mouth area (Figure 2). Between late May and 15 July two 25 fm, 8-1/2 inch mesh set gillnets and one 25 fm, 5-1/2 inch mesh set gillnet were fished at each site for king and summer chum salmon. From 16 July through 30 August two 25 fm, 6 inch mesh set gillnets were fished at each site for fall chum and coho salmon. Department biologists attribute the early portion of the fall chum run to the Porcupine stocks, while the later portion of the run is thought to be Tanana drainage stocks.

Results indicate that the king and summer chum salmon runs were early in 1980, with peaks on 18 June and 3 July for each species, respectively (Crawford 1980a). The early run timing is probably a result of the early ice breakup on the lower Yukon River (19 May) and the relatively ice-free conditions in the Bering Sea (Crawford 1980b). Fall chum salmon run timing was apparently late for the Porcupine drainage stocks (peak on 26 July), and about average for the Tanana drainage stocks (peak on 7 August). Coho salmon run timing was normal with the peak catch on 30 August. Magnitude of the catches indicated above average king and summer chum salmon runs, average coho and Tanana fall chum salmon runs, and a below average Porcupine fall chum salmon run.

Aerial Surveys

Salmon escapements in the Yukon River drainage are primarily assessed by aerial survey because of the immense size of the area and the great distances

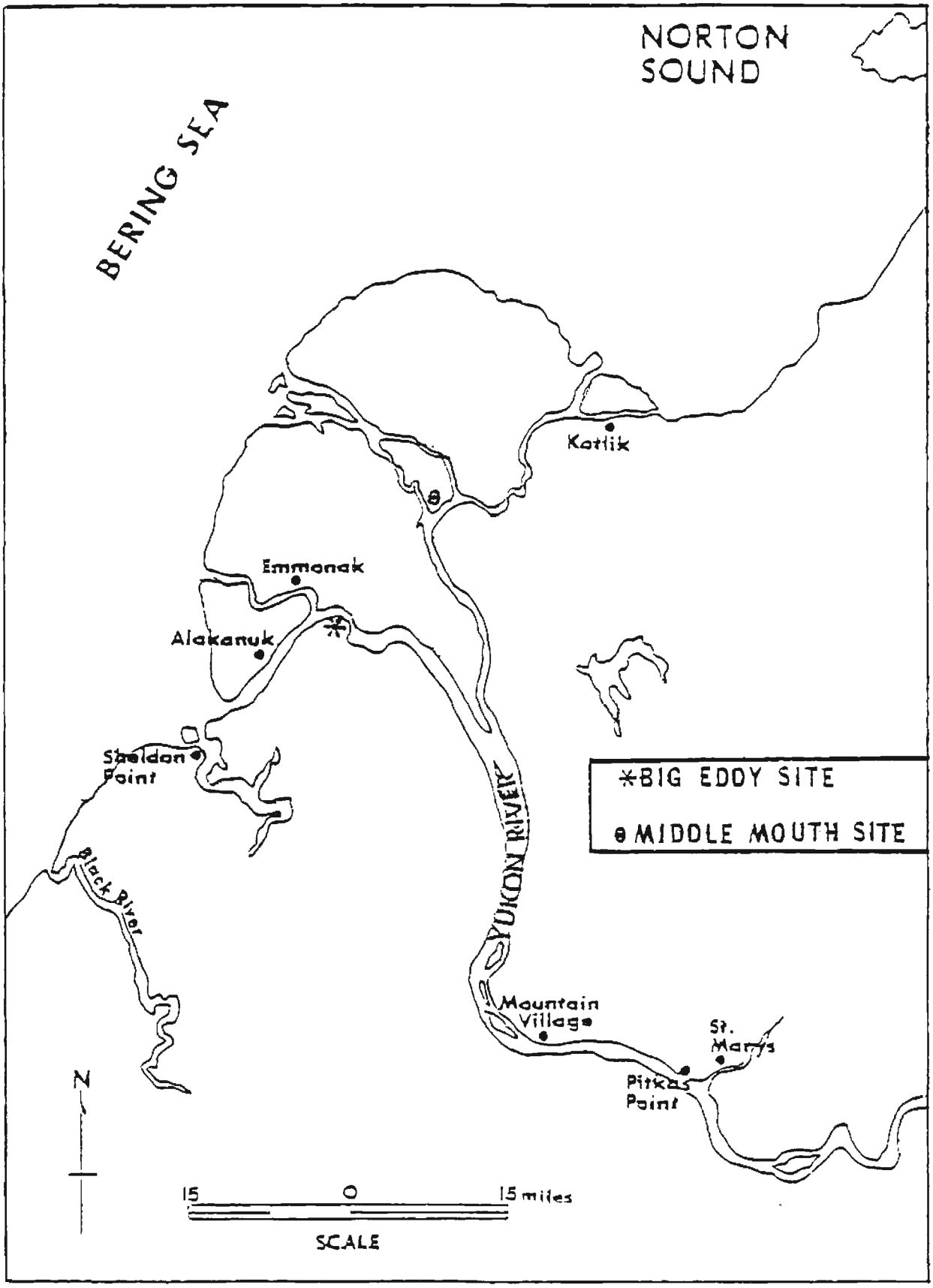

Figure 2. Map of the Yukon River mouth showing the test fishing sites.

between salmon spawning streams. Index streams have been chosen as indicators of overall Yukon River drainage escapement. During the peak of spawning, and when water and light conditions are optimal, these streams are surveyed at least once from single engine aircraft. While not precise, aerial surveys are an important tool for assessing stock status and management strategy.

King salmon escapements in most index spawning areas in 1980 ranged from average to above average (Table 1). Record escapements were documented in the Gisasa River, Chena River, Salcha River, and several streams in the Yukon Territory, Canada. The Whitehorse Dam fishway count of 1,383 king salmon was exceeded only by the 1962 escapement of 1,500 fish.

Summer chum salmon escapements were average to above average throughout the drainage (Table 2). Combined total escapement in the Anvik and Andreafsky River systems, the major summer chum salmon producers, was estimated at 633,800 fish. Throughout the Yukon River drainage a total of 704,900 summer chum salmon were counted in escapement surveys. Fall chum salmon escapements were generally below average, but similar to the 1976 parent year escapement levels (Table 3). The Toklat River in Alaska and the Fishing Branch River in Yukon Territory, Canada, the two major fall chum producers, had observed escapements of 25,194 and 20,319 fish, respectively.

Program Expansion

The Alaska State Legislature appropriated $1.2 million in 1980 for the immediate expansion of the Yukon area salmon research and management program. As a result of this funding, two new research biologists have been added to the staff, and several new projects are being implemented.

1) Enumerate salmon escapement to the Andreafsky, Melozitna, Sheenjek, and Tanana Rivers using newly purchased side scan sonar counters.

2) Test the feasibility of counting salmon in the main Yukon River near Pilot Station using a fan scan sonar counter developed by the Bendix Corporation (Bendix 1979).

3) Monitor chum and coho salmon run strength and timing in the upper Yukon River at Kaltag and Ruby by test fishing with fishwheels.

4) Increase aerial survey coverage of important spawning tributaries.

5) Test the feasibility of identifying discrete stocks of king salmon by scale pattern analysis.

6) Enter commercial fishery statistics on computer file and develop statistical models to improve management precision.

Table 1. Yukon River drainage king salmon escapement estimates, 1973-1980[1].

	1973	1974	1975	1976	1977	1978	1979	1980	Average
Salcha River	249	1,857	1,055	1,691	1,202	3,499	4,789	6,757	2,637
Andreafsky East	825	-	993	818	2,008	2,487	1,180	958[2]	1,324
Anvik River	613[3]	506[4]	720[5]	1,155[5]	1,354[5]	1,281[5]	1,474[3]	1,330	1,054
Chena River	21	1,035[6]	316[6]	531	563	1,726	1,159	2,541	986
Andreafsky West	788	285	421	643	1,499	1,062	1,134	1,500	916
Nulato River	-	78	204	548	487	920	1,507	1,323	738
Whitehorse Dam	228	273	313	120	277	670	1,150	1,383	552
Nisutlin River	36[2]	48[2]	249	102	77	375	713	975	322

[1] Based on aerial survey estimates, except for the Whitehorse Dam, which is a fishway count.

[2] Poor survey conditions. Number is a minimum estimate.

[3] Includes counting tower estimate.

[4] Tower count.

[5] Includes boat survey.

[6] Boat survey count.

Table 2. Summer chum salmon escapement to the major spawning areas in the Yukon River drainage, 1976-1980[1].

	1976	1977	1978	1979	1980	Average
Anvik River	406[2]	263[2]	251[2]	281[3]	482[3]	337
Andreafsky East	105	113	127	66	37[4]	90
Andreafsky West	118	63	57	43	115	79
Nulato River	49	70	54	37	15	45
Rodo River	38	16	18	-	-	24
Hogatza River	20	11	5	14	20	14
Gisasa River	21	2	9	11	10	11
Salcha River	6	0.7	5	3	4	3.7
Melozitna River	3	1	6	2	6	3.6
Chena River	0.7	0.7	1.6	1.0	0.3[4]	0.9

[1] In thousands of fish. Based on aerial survey estimates.

[2] Includes counting tower estimates.

[3] Sonar estimate.

[4] Poor survey conditions. Number is a minimum estimate.

Table 3. Fall chum salmon escapement to the major spawning areas in the Yukon River drainage, 1976-1980[1].

	1976	1977	1978	1979	1980	Average
Toklat River	37.2[3]	25.0	35.0	172.1	25.2	58.9
Fishing Branch River	13.4	32.5	15.0	44.1	20.3	25.1
Sheenjek River	12.0	20.5	14.6	41.1	13.0	20.2
Delta River	5.5	17.9	10.1	8.1	4.6	9.2
Tanana South Bank[2]	5.0	3.7	5.7	20.8	3.4	7.7
Bluff Cabin Slough	3.2	6.5	5.3	6.9	3.2	5.0
Chandalar River	0.1[3]	4.2	-	-	3.0	2.4
Delta Clearwater Slough	1.6	1.9	0.5	3.8	0.9	1.7
Benchmark Slough	0.3	1.3	1.7	2.7	1.6	1.5

[1] In thousands of fish. Based on aerial survey estimates.

[2] Richardson Highway bridge to Blue Creek.

[3] Poor survey conditions. Number is minimum estimate.

ANVIK RIVER SALMON ESCAPEMENT STUDY

Introduction

The Anvik River (Figure 3) is located 318 mi upstream from the mouth of the Yukon and is the single most important chum salmon producer in the entire Yukon River drainage. In addition, the Anvik River ranks third in king salmon production, following the Salcha and Andreafsky Rivers.

Studies were initiated on the Anvik River in 1971, when the river was surveyed and the feasibility of enumerating salmon from a counting tower was tested. The project was continued in 1972. Between 1973 and 1975, a counting tower was operated approximately 5-1/2 mi above the confluence of the Yellow River (Figure 3). The tower was moved downstream to a site near Robinhood Creek in 1976, where it remained until 1979. High and turbid water often affected the accuracy of visual counts and an alternate method of escapement enumeration was desirable.

The Electrodynamics Division of the Bendix Corporation developed a side scanning hydroacoustic counter during the 1970's capable of detecting and counting salmon migrating along the banks of tributary streams. The side scan sonar counter is designed to transmit a sonar beam along a 60 ft metal pipe, or substrate. Fish passing through the beam transmit echoes to the transducer. The system electronics interpret the strength of the echoes, and tally salmon counts. The side scan sonar counter was tested on the Anvik River in conjunction with visual counting at the Robinhood Creek site in 1976, 1977, and 1978. Results indicated that accuracy of the sonar counter exceeded 95% as compared to visual counts (Bendix 1976). The sonar counter was installed at mile 48 on the Anvik River, near Theodore Creek in 1979, and was successful in enumerating chum salmon escapement. The tower counting method was terminated at the conclusion of the 1979 field season since the sonar counting method had proven feasible and superior.

Methods and Materials

Two side scan sonar counters were installed at mile 48 on the Anvik River, near Theodore Creek (Figure 3). The 60 ft west bank substrate was installed 27 June on a gradually sloping sand bar, with the inshore transducer end 2 ft underwater. About 15 ft of shallow water between the shore and the transducer was fenced to prevent salmon passage. The 40 ft east bank substrate was installed 29 June on a cut bank about 100 ft downriver from the west bank substrate. The inshore transducer end was 2 ft underwater and rested directly against the bank.

Sonar counts were totaled electronically in twelve sectors for each substrate and printed hourly. When the machine detects that counts are being caused by debris, the letter "D" is printed in the appropriate sector. Sector counts missing because of debris or printer malfunction were interpolated by averaging the counts from the sector before and after the missing sector. For sectors 1 and 12, the counts from sector 2 and 11 were used, respectively.

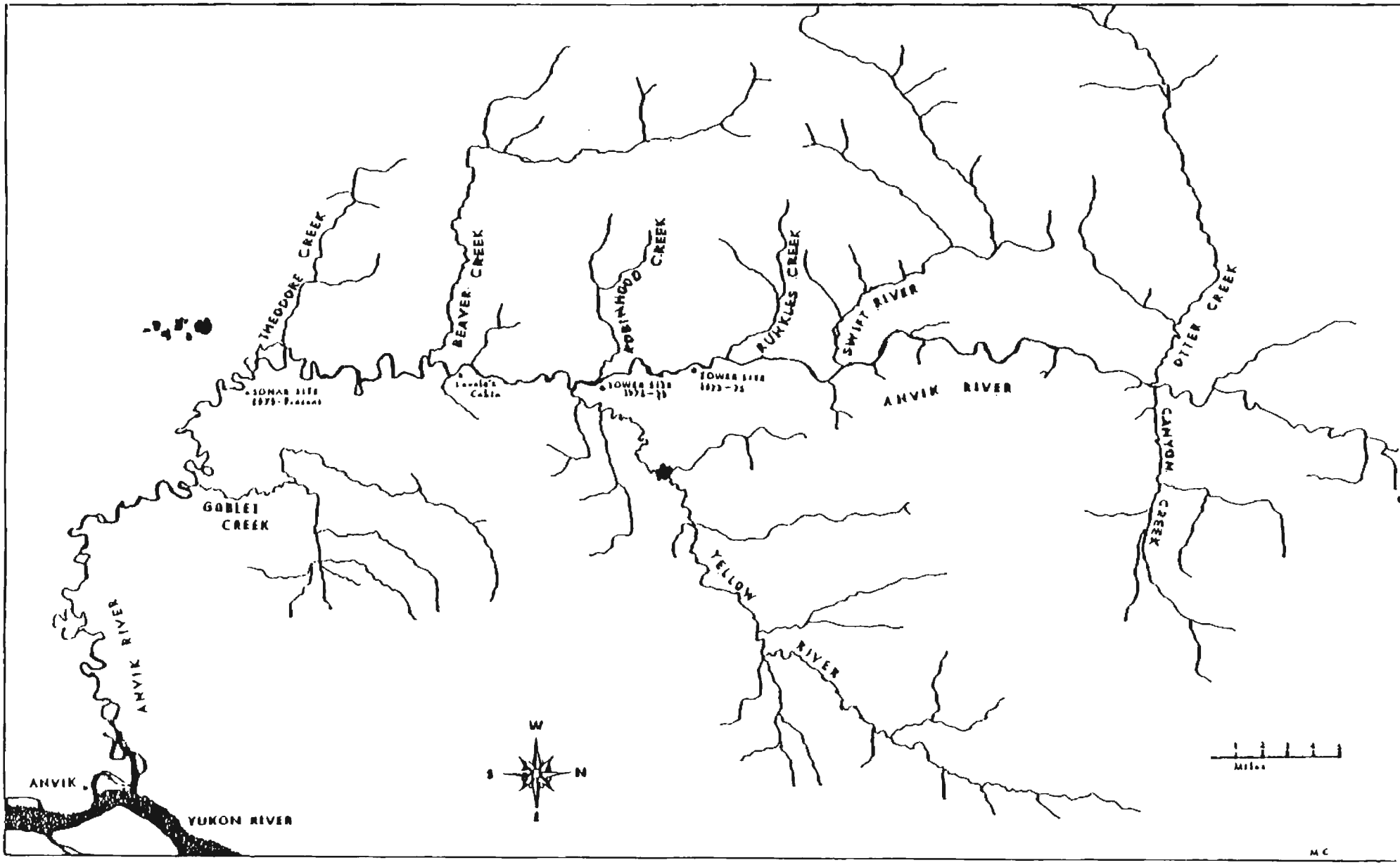

Figure 3. Map of the Anvik River.

Hourly sector counts were totaled daily for each substrate. The daily sum of east and west bank counts was inflated by 10% to account for escapement through the middle 100 feet of the river which was not covered by the sonar counters. The 10% midstream escapement estimate is based on visual observations conducted in 1978 (Appendix A). Since chum salmon outnumbered king salmon by about 325 to 1 in 1980, and the sonar electronics does not distinguish between the two species, all adjusted sonar counts were attributed to chum salmon escapement. Separate escapement estimates for king salmon were obtained from aerial surveys.

King and chum salmon carcasses were sampled from sand bars for age, length, and sex ratio data between 20 July and 20 August. Sampled fish were measured from midorbit to fork of tail in millimeters. Three scales were removed from an area posterior to the base of the dorsal fin and above the lateral line on the left side of the fish. The body cavity was opened for positive sex identification. Scale samples were later pressed on acetate cards and the resulting impressions viewed on a microfiche reader for age determination.

Results and Discussion

The sonar counters were operated between 27 June and 25 July 1980. Beginning on 12 July and continuing until termination of the project, chum salmon milling over the substrates caused multiple counts and resulted in inflated daily escapement estimates. It was not possible to visually document the magnitude of the problem on the east bank substrate, nor on the outer half of the west bank substrate. However, during occasional periods of relatively clear water visual calibration of the inshore half of the west bank substrate was possible. Adjustment formulas were developed based on the visual observations (Appendix A), and then applied to the daily sonar counts from 12 to 25 July. The resulting season chum salmon escapement estimate if 482,181 fish (Table 4).

The river was surveyed from a fixed wing aircraft on 24 July 1980 and 337,590 chum and 1,330 king salmon were counted. Peak aerial survey counts are generally lower than the cumulative sonar or tower count because of turbid water and the die-off of early spawners. In addition, not all spawning creeks are surveyed by aircraft. While flying the aerial survey it was observed that the west bank substrate was in the center of a chum spawning bed, but that there were virtually no spawners 100 ft downriver. It is recommended that in the future the west bank substrate be installed 100 ft downriver to avoid the spawner milling problem.

The 1980 escapement estimate of 482,181 chum salmon is 18% greater than the previous 5-year average of 409,256 chum salmon, and 19% greater than the 1976 parent year escapement estimate of 406,166 chum salmon. Run timing of the 1980 escapement was similar to that of 1979 (Figure 4). Previous escapements were counted at several different sites, and run timing is not directly comparable.

The 50% point in the migration was reached on 8 July in 1979 and on 11 July in 1980. Peak daily counts in 1980 of 25,744, 31,980, and 33,689 chum

Table 4. Anvik River chum salmon sonar counts by river bank and date, 1980.

Date	Expanded Counts[1]		Escapement Estimate[2]		Percent of Season Total	
	West Bank	East Bank	Daily	Cumulative	Daily	Cumulative
6/27	677	-	839	839	-	-
6/28	2,974	-	3,688	4,527	1	1
6/29	5,732	924	7,604	12,131	2	3
6/30	13,773	2,162	17,528	29,659	4	7
7/ 1	21,573	1,831	25,744	55,403	5	12
7/ 2	19,114	998	22,123	77,526	5	17
7/ 3	10,023	793	11,898	89,424	2	19
7/ 4	7,057	1,220	9,105	98,529	2	21
7/ 5	12,367	2,269	17,000	115,529	4	25
7/ 6	14,151	1,130	16,809	132,338	3	28
7/ 7	7,696	2,192	10,877	143,215	2	30
7/ 8	14,089	3,256	19,080	162,295	4	34
7/ 9	14,075	2,690	18,442	180,737	4	38
7/10	26,118	2,955	31,980	212,717	7	45
7/11	23,267	3,938	29,926	242,643	6	51
7/12	23,195	4,959	17,757	260,400	4	55
7/13	28,546	5,206	23,542	283,942	5	60
7/14	29,015	1,313	30,746	314,688	6	66
7/15	35,044	8,819	33,689	348,377	7	73
7/16	42,622	12,755	29,092	377,469	6	79
7/17	36,877	12,700	23,053	400,522	5	84
7/18	30,865	21,447	29,042	429,564	6	90
7/19	29,124	49,702	19,761	449,325	4	94
7/20	25,752	30,431	14,676	464,001	3	97
7/21	23,594	14,347	8,117	472,118	2	99
7/22	24,079	7,135	6,202	478,320	1	100
7/23	24,313	7,770	814	479,134	-	100
7/24	22,536	11,415	1,450	480,584	-	100
7/25	20,565	8,754	1,597	482,181	-	100

[1] Sonar counts expanded for missing sectors and debris sectors by averaging the counts from the sector before and after the missing sector. Sector 1 and 12 were estimated by using the counts from sector 2 and 11, respectively.

[2] In order to obtain a daily escapement estimate from the sonar counts, adjustments were made to account for midstream escapement and chum salmon spawning activity along the sonar substrate. Detailed adjustment formulas are presented in Appendix A.

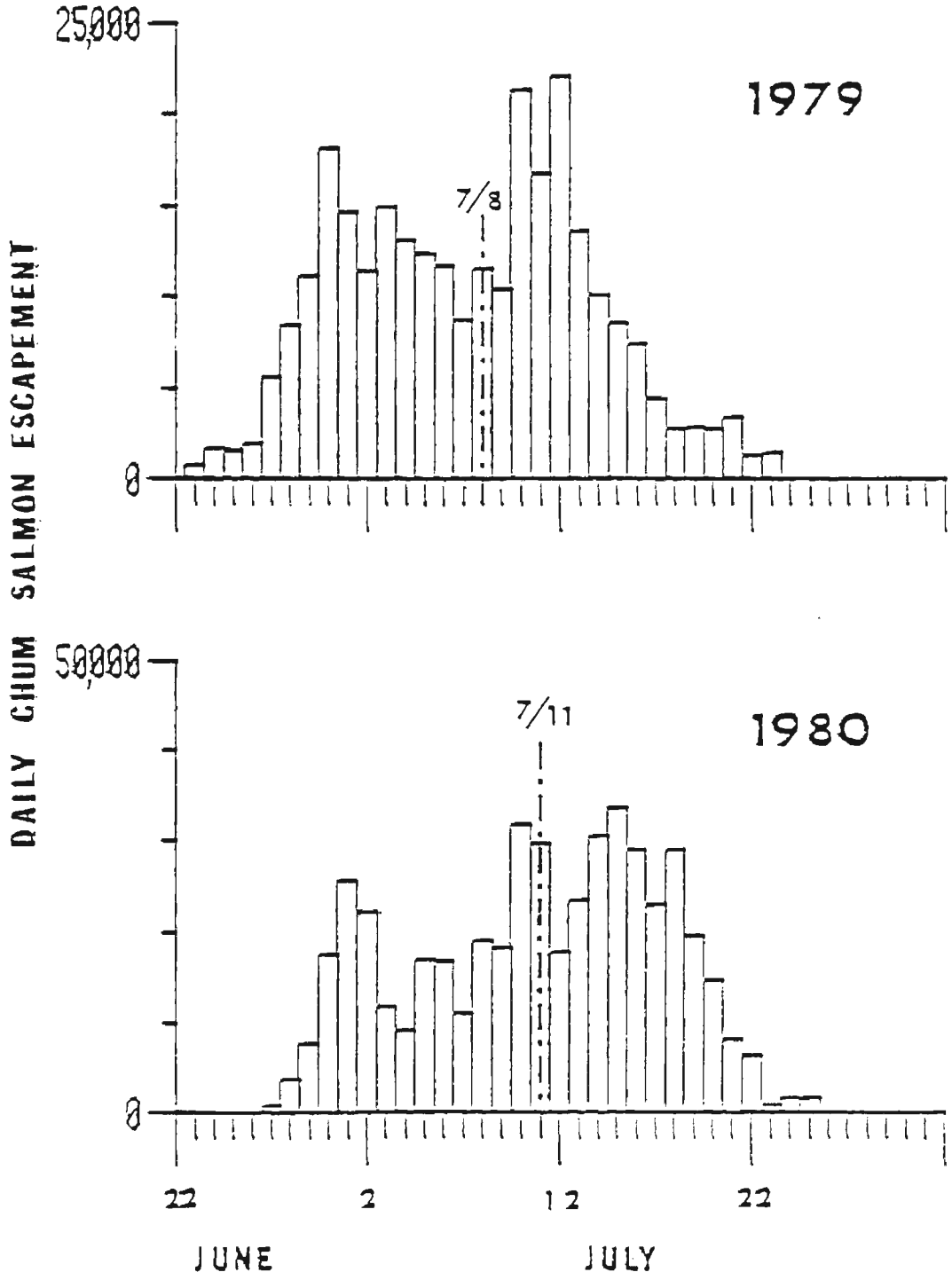

Figure 4. Daily chum salmon escapement past the Anvik River sonar site, 1979 and 1980. The date of 50% run passage for each year is indicated with dotted lines.

salmon occurred on 1, 10, and 15 July, respectively (Table 4). Mundy (1979) states that salmon migratory timing is a genetically transmitted character that tends to be conservative across generations. Although affected by environmental conditions, percent run passage tends to form a pattern which can be used as a predictive tool.

A total of 425 chum salmon carcasses was sampled for age[1] and length and later proved to have readable scales. Of the total, one chum salmon was age 3_1, 373 (88%) were age 4_1, and 51 (12%) were age 5_1 (Table 5). Sixty-one percent of the sample was female, 39% male. Males were larger than females in each age class (Table 5). A total of 4,835 chum salmon carcasses have been sampled from the Anvik River since 1972, with a combined sample breakdown of 261 (5%) age 3_1, 3,144 (65%) age 4_1, 1,411 (29%) age 5_1, and 19 ($\leq$ 1%) age 6_1 (Appendix Table 1). Fifty-six percent of the total sample has been female, 44% male. The predominance of age 4_1 chum salmon is similar to that found in other areas of Alaska (Thorsteinson, Noerenberg, and Smith 1963).

A total of 83 king salmon carcasses was sampled for age and length and later proved to have readable scales. Of the total, 20 (24%) were age 4_2, 43 (51%) were age 5_2, 17 (20%) were age 6_2, and 3 (4%) were age 7_2 (Table 6). Fifty-one percent of the sample was female, 49% male. Females were larger than males in each age class (Table 6). A total of 401 king salmon carcasses have been sampled from the Anvik River since 1972, with a combined sample breakdown of 61 (15%) age 4_2, 144 (36%) age 5_2, 182 (45%) age 6_2, and 14 (3%) age 7_2 (Appendix Table 2). Fifty-seven percent of the total sample has been male, 43% female.

TANANA RIVER FALL CHUM AND COHO SALMON TAGGING STUDY

Introduction

State funds became available in July 1976 to conduct a tagging study of Yukon River fall chum salmon. Results of studies conducted from 1976 through 1978 indicated that the majority of fall chum salmon migrating along the north bank of the Yukon River in the Galena-Ruby area (Figure 1) were upper Yukon River stocks, while chum salmon migrating along the south bank were primarily Tanana River stocks (Mauney 1980). The tagging study was conducted on the Tanana River in 1979 to determine whether upper Tanana and Toklat River chum salmon stocks could be separated by run timing and/or bank orientation in the lower Tanana River near Manley Hot Springs.

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[1] Ages designated by Gilbert-Rich formula: years of total life in superscript, years of freshwater life in subscript.

Table 5. Age, length, and sex ratio of chum salmon carcasses sampled from the Anvik River in July, 1980[1].

	Age 3_1			Age 4_1			Age 5_1			Total		
		Length			Length			Length			Length	
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Male	0 (-)	-	-	147 (35%)	568	25	20 (5%)	608	26	167 (39%)	573	28
Female	1 (-)	501	-	226 (53%)	530	23	31 (7%)	564	22	258 (61%)	534	25
Total	1 (-)	501	-	373 (88%)	545	30	51 (12%)	582	32	425 (100%)	549	33

[1] Ages designated by Gilbert-Rich formula: years of total life in superscript, years of freshwater life in subscript. Lengths measured from mid-orbit to fork of tail in millimeters. Numbers in parentheses are percent of total sample made up by the given age-sex group.

Table 6. Age, length, and sex ratio of king salmon carcasses sampled from the Anvik River in July and August, 1980[1].

	Age 4_2			Age 5_2			Age 6_2			Age 7_2			Total		
		Length			Length			Length			Length			Length	
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Male	19 (23%)	582	28	21 (25%)	735	48	1 (1%)	870	-	0 (-)	-	-	41 (49%)	668	92
Female	1 (1%)	605	-	22 (26%)	782	44	16 (19%)	886	33	3 (4%)	970	76	42 (15%)	831	82
Total	20 (24%)	584	28	43 (51%)	759	51	17 (20%)	885	32	3 (4%)	979	76	83 (100%)	750	119

[1] Ages designated by Gilbert-Rich formula: years of total life in superscript, years of freshwater life in subscript. Lengths measured from mid-orbit to fork of tail in millimeters. Numbers in parentheses are percent of total sample made up by the given age-sex group.

The Toklat River has accounted for an average 70% of the Tanana River fall chum spawning escapement in the years 1976-1980, as compared to only 30% for the Tanana River drainage upstream of the Kantishna River confluence (Table 7). The Toklat stock could probably support greater harvest in some years. However, management regulations formulated to increase the harvest of Toklat chums must at the same time allow for continued escapement of upper Tanana stocks at present levels.

Methods and Materials

Two fishwheels were rented under contract from local fishermen and operated in the lower Tanana River near Manley Hot Springs in August and September of 1979 and 1980. Each wheel was equipped with a live box to hold the fish until they could be tagged and released. Captured chum and coho salmon in good condition were identified by sex and tagged with an individually numbered orange (south bank wheel) or yellow (north bank wheel) "spaghetti" type plastic tag. A subsample of the catch was measured for length from tip of snout to fork of tail, in millimeters, and a scale taken for age determination. Not all chum and coho salmon captured were tagged, although the number of fish captured was recorded for each wheel each day.

A 2 dollar reward was paid for each tag returned by fishermen. The date, location, and method of recovery was reported with the tag returns. In addition, Department personnel conducted spawning ground surveys in October and November of 1979 and 1980 for tag recoveries on the Toklat River, Delta River, Clearwater Lake outlet, Delta Clearwater River, Bluff Cabin Slough, Benchmark Slough, and the south bank of the Tanana River near the Richardson Highway bridge.

Results and Discussion

Results of the 1979 tagging study were originally reported by Mauney and Buklis (1980). Late tag returns have altered the figures slightly, and the most current data is included here, although the discussion will focus on the 1980 study.

In 1979 one fishwheel was located on the north bank of the Tanana River 8 mi below Manley Hot Springs, while the second wheel was on the south bank, 40 mi below the village. To rigorously test for a difference in bank orientation between stocks, the two fishwheels should be located directly opposite each other. A second factor, besides bank orientation, is introduced when the tagging sites are located some 32 mi apart. It is unknown whether differences in tag recoveries in the upper Tanana and Toklat Rivers are a function of the river bank of tagging or to the river mile of tagging. In an attempt to resolve this problem, the two fishwheels were located within 4 mi of each other in 1980. One wheel was again located on the north bank, 8 mi below Manley Hot Springs, while the other was on the south bank, 4 mi below the village. It is difficult to locate an adequate fishwheel site on the south bank of the Tanana River near Manley Hot Springs because of shallow water and slack current, and a 4 mi separation between fishwheels was considered acceptable.

Table 7. Tanana River fall chum salmon escapement, 1976-1980[1].

	1976	1977	1978	1979	1980	Average
Upper Tanana River						
Delta River	5.5	17.9	10.1	8.1	4.6	9.2
Tanana South Bank[2]	5.0	3.7	5.7	20.8	3.4	7.7
Bluff Cabin Slough	3.2	6.5	5.3	6.9	3.2	5.0
Delta Clearwater Slough	1.6	1.9	0.5	3.8	0.9	1.7
Benchmark Slough	0.3	1.3	1.7	2.7	1.6	1.5
Total Upper Tanana River	15.6 (30)	31.3 (56)	23.3 (40)	42.3 (20)	13.7 (35)	25.1 (30)
Toklat River	37.2 (70)	25.0 (44)	35.0 (60)	172.1 (80)	25.2 (65)	58.9 (70)
Total Tanana River Drainage	52.8	56.3	58.3	214.4	38.9	84.0

[1] In thousands of fish. Estimated by aerial survey. Numbers in parentheses are percent of total Tanana River escapement observed in the upper Tanana and Toklat Rivers.

[2] Richard Highway bridge to Blue Creek.

However, few chum salmon were captured for tagging and difficulty in locating a suitable fishwheel site on the south bank forced a change in the design of the study. The south bank fishwheel was moved on 2 September to the north bank, 10 mi below Manley Hot Springs and 2 mi below the original north bank fishwheel. The original north bank wheel will be referred to henceforth as fishwheel #1, and the wheel 2 mi downriver will be referred to as fishwheel #2.

Chum salmon catches were consistently lower in the south bank fishwheel than either of the north bank wheels (Appendix Table 3). Dropping water levels forced the selection of a new south bank fishwheel site on 18 August, and during the following 12-day period six new sites were fished with little success. Gillnets (5-7/8 in mesh, 100 ft long) were fished on 29 August at two potential sites on the south bank to obtain an index of chum salmon abundance. One net caught one chum salmon, while the other caught no fish during a 17-hour set. The north bank wheel #1 had captured 771 chum salmon by 29 August, while the south bank wheel had captured only 172 (Appendix Table 3).

A total of 4,365 chum salmon was captured by fishwheel #1 between 14 August and 26 September, while 3,203 chum salmon were captured by fishwheel #2 between 3 and 28 September (Appendix Table 3). Peak catches for fishwheel #1 of 369 and 351 chum salmon occurred on 9 and 15 September, respectively. Peak catches for fishwheel #2 of 402 and 335 chum salmon occurred on 12 and 15 September, respectively. A total of 2,453 chum salmon was tagged from fishwheel #1 and 2,660 were tagged from fishwheel #2 (Appendix Table 4). Out of the 172 chum salmon captured on the south bank of the river before the fishwheel was moved, 166 were tagged.

A total of 412 coho salmon was captured by fishwheel #1 between 29 August and 26 September, while 341 coho salmon were captured by fishwheel #2 between 3 and 28 September (Appendix Table 5). No cohos were recaptured on the south bank. The peak catch for fishwheel #1 of 104 coho salmon occurrred on 26 September, the last day the wheel was operated. The peak catch for fishwheel #2 of 57 coho salmon occurred on 27 September. A total of 366 coho salmon was tagged from fishwheel #1 and 333 from fishwheel #2 (Appendix Table 6).

One thousand two hundred thirty-four chum salmon (23%) were recaptured. The majority of the fish were recaptured by fishwheel (46%), with gillnets (28%) and spawning ground surveys (22%) providing the remainder (Table 8). Similar results were obtained in 1979. One hundred seventy-seven coho salmon (25%) were recaptured. Fishwheels (44%) and gillnets (44%) produced an equal number of recaptures, with spawning ground surveys (3%) and hook and line gear (1%) providing the remainder (Table 8).

The reported subsistence harvest of 50,328 chum salmon produced 717 tag returns, while the commercial harvest of 19,520 chum salmon produced 193 tag returns (Table 9). The tagged:untagged chum ratio was thus 1:70 for the subsistence fishery and 1:101 for the commercial fishery. The difference in tag recovery rates between the two fisheries may be a result of: (1) the commercial fishery operated for only 6 days (9/12 to 9/17) while the subsistence fishery operated throughout the tagging period, and (2) subsistence

Table 8. Tanana River chum and coho salmon tag recoveries by gear type, 1979 and 1980.

	CHUM				COHO			
	1979		1980		1979		1980	
	N	%	N	%	N	%	N	%
Fishwheel	593	44	569	46	15	42	78	44
Gillnet	307	23	347	28	9	25	77	44
Hook & Line	3	-	0	0	7	19	1	1
Hand Picked	374	28	274	22	2	6	6	3
Unknown	69	5	44	4	3	8	15	8
Total	1,346	100	1,234	100	36	100	177	100

Table 9. Tanana River chum and coho salmon tag recoveries by fishing activity, 1979 and 1980.

	CHUM				COHO			
	1979		1980		1979		1980	
	N	%	N	%	N	%	N	%
Subsistence	673	50	717	58	21	58	136	77
Commercial	260	19	193	16	6	17	27	15
Sport	4	-	0	-	7	19	1	1
Spawning Ground Survey	375	28	274	22	2	6	6	3
Unknown	34	3	50	4	0	0	7	4
Total	1,346	100	1,234	100	36	100	177	100

fishermen probably under-reported their harvest. Similar tag recovery rates were found in 1979.

A Petersen population estimate (Ricker 1975) of the Tanana fall chum run was calculated using the following formulas:

$$\hat{N} = \frac{(M + 1)(C + 1)}{(R + 1)}$$

Where M = tagged fish released
C = catch upstream of tag site
R = tagged fish recaptured

$$\hat{V(N)} = \frac{(M + 1)^2 (C + 1) (C - R)}{(R + 1)^2 (R + 2)}$$

$$95\% \text{ Confidence Interval (CI)} = \sqrt{\hat{V(N)}} (\pm 1.96)$$

The following values were used for the variables:

Commercial catch	19,520
Subsistence catch	50,328
Chum salmon tagged (8/14 - 9/17)[1]	3,869
Chum salmon tagged (total)	5,279
Commercial returns	193
Subsistence returns	717
Unspecified returns	50

The resulting population estimates are as follows:

Data Source	Population Estimate	95% C.I.
Commercial Fishery	389,414	± 54,385 (± 14%)
Subsistence Fishery	370,107	± 26,860 (± 7%)

[1] This value was used as the number of tagged fish released (M) when calculating a population estimate based on returns from the commercial fishery. Since the commercial fishery did not operate after 9/17, fish tagged after that date were not available for recapture.

Data Source	Population Estimate	95% C.I.
Both Fisheries Combined	383,770	± 24,084 (± 6%)

The best estimate is probably the one combining the data from both fisheries, since it uses the largest data base and has the smallest relative confidence interval. Both fisheries combined is the sum of commercial and subsistence harvests and tag returns. The harvest exploitation rate (R/M) is 17%.

All three population estimates seem high. The sum of harvest and observed escapement was 108,817 chum salmon, leaving some 275,000 (or 72%) unaccounted for in the Tanana River drainage. In 1979, the population was estimated at 796,963 chum salmon. The sum of harvest and observed escapement was 300,583 chum salmon, leaving some 496,000 (or 62%) unaccounted for in 1979. The true population size for each year is probably between the documented number (catch plus observed escapement) and the population estimate since:

1) The documented number is an underestimate because of unreported harvests and the difficulty in obtaining accurate aerial survey escapement counts in the glacial Tanana drainage. Aerial survey counts are "peak index counts" and do not include early or late spawners, and

2) Tags returned may not be the actual number recovered because of failure of some fishermen to return tags.

The recovery of tagged chum salmon in the upper Tanana and Toklat Rivers in 1979 indicated a slight difference in bank orientation between the two stocks in the lower Tanana River. Fifty-nine percent of the chum salmon recovered in the upper Tanana had been tagged at the north bank fishwheel (Table 10). Conversely, 65% of the chum salmon recovered in the Toklat had been tagged at the south bank fishwheel. This is not a strong separation, and in fact may be the result of the river mile of tagging as much as the bank of tagging. Since only 166 chum salmon were tagged on the south bank in 1980, comparison of bank orientation between the stocks is not meaningful for that year (Table 11). Based on the weak separation measured in 1979, and the inability to capture an adequate number of fish on the south bank in 1980, it does not appear that the upper Tanana and Toklat River fall chum salmon stocks can be distinguished by bank orientation in the lower Tanana River near Manley Hot Springs.

Department personnel conducted spawning ground surveys of the Toklat and upper Tanana Rivers. A total of 25,310 chum salmon was observed in the Toklat River drainage by foot survey and 242 tags were recovered, for a tagged:untagged chum salmon ratio of 1:105 (Table 12). A total of 7,425 chum salmon was observed in the upper Tanana River drainage by foot survey and 18 tags were recovered, for a tagged:untagged chum salmon ratio of 1:412 (Table 13). The difference in tag recovery rates is probably due to the fact that the upper Tanana stocks pass through several fisheries upstream of the Kantishna River confluence, whereas the Toklat stocks is virtually unintercepted between the Manley Hot Springs fishery and the spawning grounds.

Table 10. Tanana River chum and coho salmon tag recoveries by recovery area, 1979.

	Tagged		Recovery Area					
			Tanana Below Kantishna		Tanana Above Kantishna		Kantishna-Toklat	
	N	%	N	%	N	%	N	%
Chum								
North Bank	3,728	51	164	37	317	59	130	35
South Bank	3,531	49	274	63	217	41	244	65
Chum Total	7,259	100	438	100	534	100	374	100
Coho								
North Bank	183	81	6	75	21	81	1	50
South Bank	42	19	2	25	5	19	1	50
Coho Total	225	100	8	100	26	100	2	100

Table 11. Tanana River chum and coho salmon tag recoveries by recovery area, 1980.

	Tagged	Recovery Area							
		Tanana Below Kantishna		Tanana Above Kantishna		Kantishna-Toklat		Total	
		N	%	N	%	N	%	N	%
Chum									
North Bank	5,113	215	18	719	61	254	21	1,188	100
South Bank	166	1	2	43	93	2	4	46	100
Coho									
North Bank	699	16	9	161	91	0	-	177	100
South Bank	0	-	-	-	-	-	-	-	-

Table 12. Number of chum and coho salmon observed and tags recovered by foot survey of Toklat River spawning grounds, 1980[1].

Location	Chum					Coho				
	Live	Carcass	Total	Tags	Ratio	Live	Carcass	Total	Tags	Ratio
Sushana River	8,750	4,100	12,850	85	1:151	5	0	5	0	-
Geiger Creek	1,900	1,400	3,300	42	1:80	10	0	10	0	-
Toklat River near Shushana	100	300	400	6	1:67	0	0	0	0	-
Unnamed Tributary Creek	2,200	3,560	5,760	46	1:125	0	0	0	0	-
Unnamed Tributary Creek	1,500	1,500	3,000	63	1:48	0	0	0	0	-
Total	14,450	10,860	25,310	242	1:105	15	0	15	0	-

[1] Streams were surveyed several times between 10/14 and 11/1. Initial population estimates were increased to account for the arrival of new fish on subsequent surveys. Ratios listed are the ratio of tagged to untagged fish. Includes only those tags recovered by Department personnel assigned to this project.

Table 13. Number of chum and coho salmon observed and tags recovered by foot survey of Upper Tanana River spawning grounds, 1980[1].

Location	CHUM					COHO				
	Live	Carcass	Total	Tags	Ratio	Live	Carcass	Total	Tags	Ratio
Delta River	2,000	200	2,200	6	1:367	1	0	1	0	-
Bluff Cabin Slough	1,000	350	1,350	2	1:675	20	0	20	1	1:20
Delta Clearwater River	100	20	120	0	-	50	0	50	0	-
Clearwater Lake Outlet	5	0	5	0	-	300	0	300	0	-
South Bank Tanana	1,500	350	1,850	1	1:1,850	0	0	0	0	-
Benchmark Slough	1,750	150	1,900	9	1:211	0	0	0	0	-
Total	6,355	1,070	7,425	18	1:412	371	0	371	1	1:371

[1] Ratios listed are the ratio of tagged to untagged fish. Includes only those tags recovered by Department personnel assigned to this project.

Addition of the Tanana River subsistence harvest (42,675 fish) and commercial harvest (12,526 fish) above the Kantishna River confluence to the number of chum salmon observed on the upper Tanana spawning grounds (7,425 fish) yields a total of 62,626 chum salmon in the upper Tanana examined for tags. Addition of 743 tags returned by subsistence and commercial fishermen upstream of the Kantishna River confluence to the 18 tags recovered in the upper Tanana spawning grounds yields a total of 761 tag returns in the upper Tanana, for a tagged:untagged chum ratio of 1:82. This compares more favorably with the tagged:untagged chum salmon ratio of 1:105 for the Toklat River.

Examination of chum salmon tag returns in terms of tagging date indicates a slight difference in run timing between the upper Tanana and Toklat River stocks in the Manley Hot Springs area. The upper Tanana stocks demonstrated an early component that is not seen in the Toklat stock. At the south bank fishwheel in 1979, 50% run passage occurred on 1 September for the upper Tanana stock and on 17 September for the Toklat stock (Figure 5). At the north bank fishwheel in 1979, 50% run passage occurred on 7 September for the upper Tanana stock and on 12 September for the Toklat stock (Figure 6). At fishwheel #1 in 1980, 50% run passage occurred on 6 September for the upper Tanana stock, and on 13 September for the Toklat stock (Figure 7). Fishwheel #2 did not start fishing until 3 September, thus missing the early component of the upper Tanana run. As a result, 50% run passage was 3 days earlier for the Toklat stock (12 September) than for the upper Tanana stock (Figure 8). Although 50% run passage was consistently earlier for the upper Tanana stock, there is great overlap in run timing with the Toklat stock. It does not appear that the run timing of upper Tanana and Toklat River fall chum salmon stocks is sufficiently discrete to allow for single stock harvest in the Manley Hot Springs area.

Coho salmon tag returns for both 1979 (Table 10) and 1980 (Table 11) indicate that the great majority of Tanana River coho salmon spawn in the upper Tanana drainage. Only 15 coho salmon were observed by foot survey on the Toklat River spawning grounds in 1980 (Table 12), while 371 were observed on the upper Tanana River spawning grounds (Table 13).

A total of 272 chum salmon was sampled for age and length from the Tanana River north bank fishwheels and later proved to have readable scales. The Tanana River fish were measured for total length and measurements later converted to standard length using conversion factors developed in 1977 (Appendix Table 7). Of the total, 23 (8%) were age 3_1, 226 (83%) were age 4_1, and 23 (8%) were age 5_1 (Table 14). Fifty-six percent of the sample was male, 44% female. Males were larger than females in each age class (Table 14).

Fifty-seven chum salmon carcasses were sampled from the Toklat River spawning grounds and later proved to have readable scales. Of the total, 2 (4%) were age 3_1, 37 (65%) were age 4_1, and 18 (32%) were age 5_1 (Table 14). Fifty-four percent of the sample was male, 46% female. Males were larger than females in each age class (Table 14).

Forty-nine chum salmon carcasses were sampled from the Delta River spawning grounds and later proved to have readable scales. Of the total, 6 (12%) were

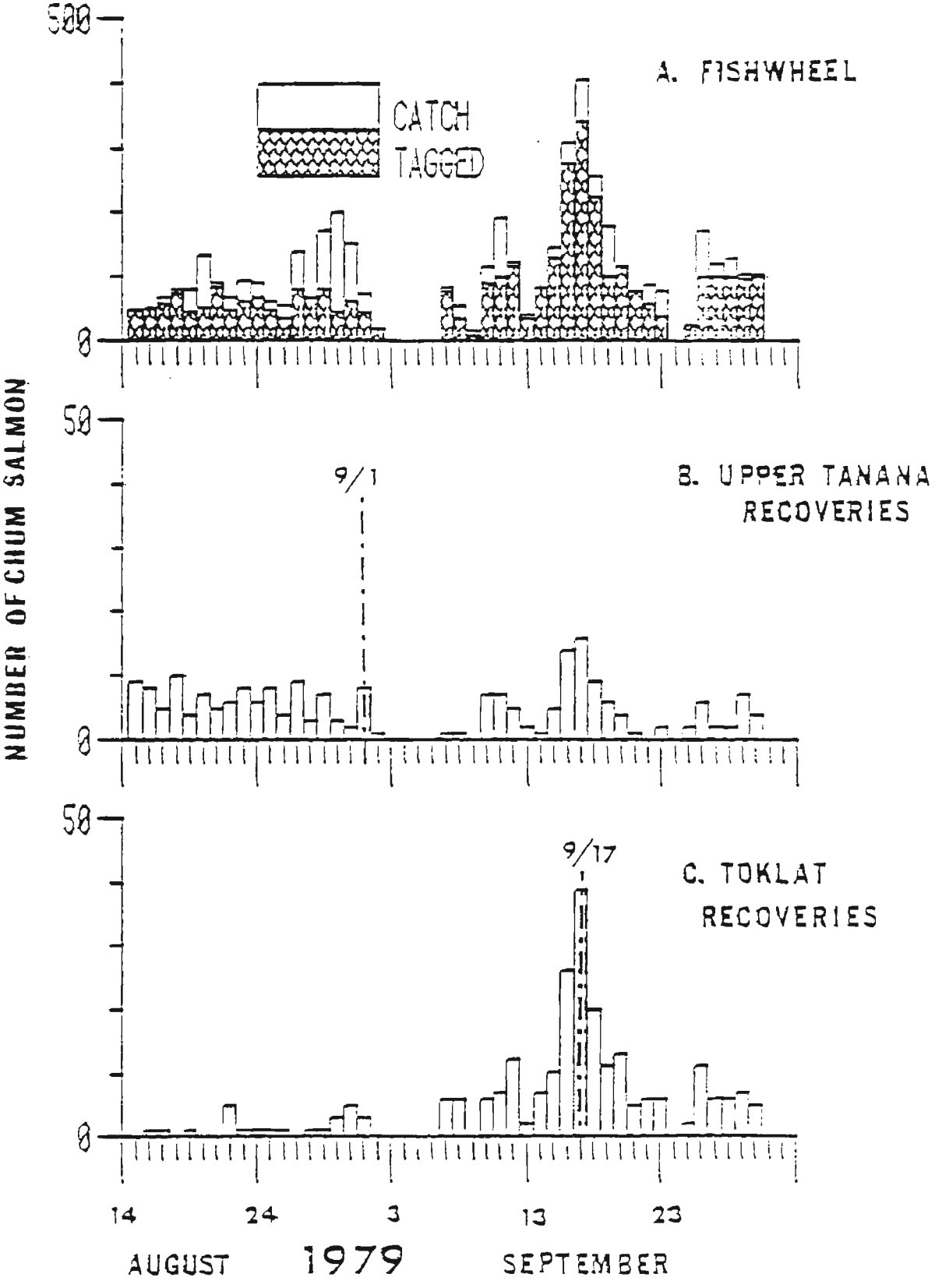

Figure 5. Run timing of fall chum salmon along the south bank of the Tanana River, 40 mi below Manley Hot Springs, in 1979, as indicated by (a) number of chums captured by fishwheel and tagged daily, (b) number of chums tagged and later recovered in the upper Tanana River, and (c) number of chums tagged and later recovered in the Toklat River. The date of 50% run passage for each stock is indicated with dotted line.

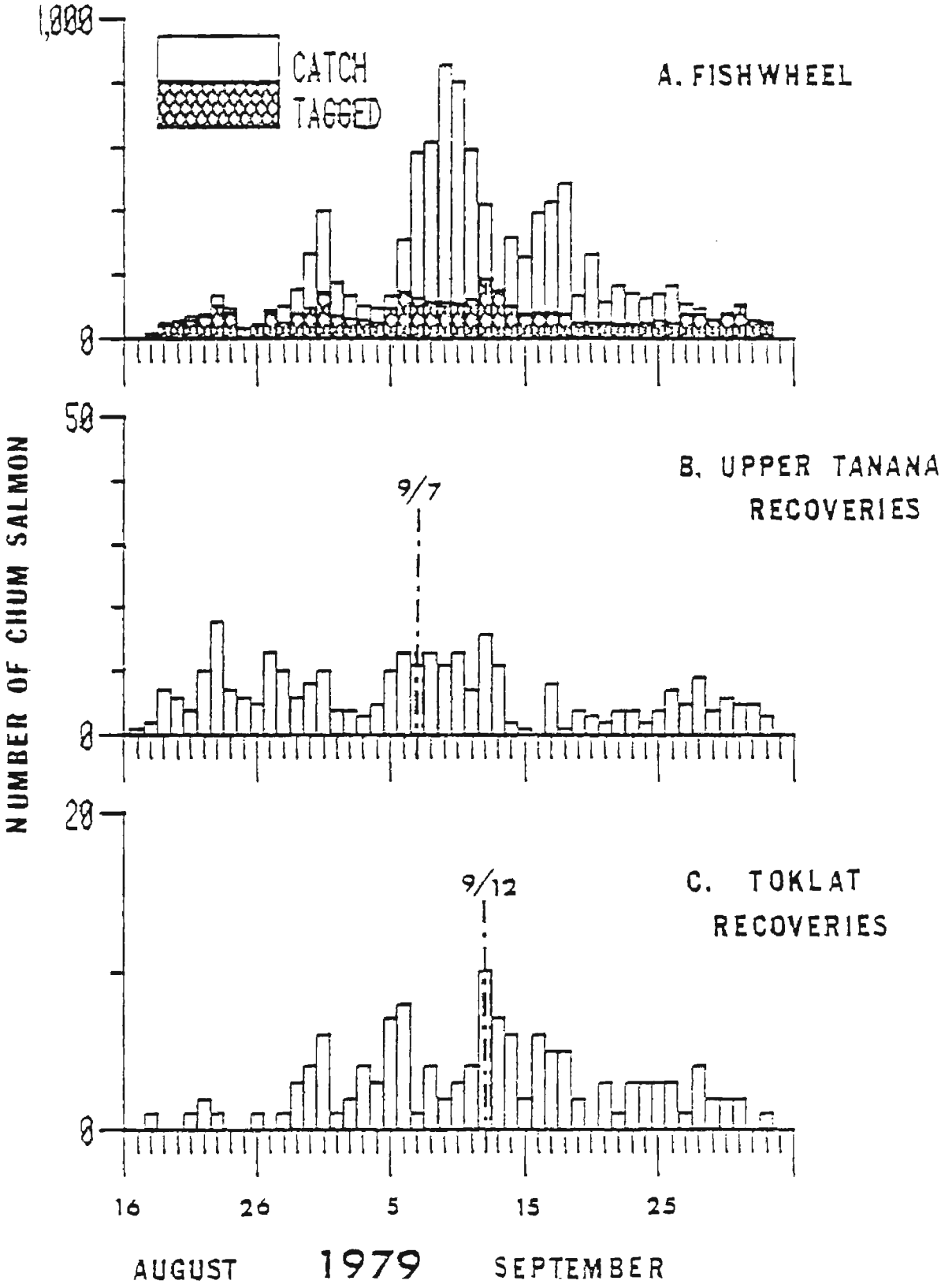

Figure 6. Run timing of fall chum salmon along the north bank of the Tanana River, 8 mi below Manley Hot Springs, in 1979, as demonstrated by (a) number of chums captured by fishwheel and tagged daily, (b) number of chums tagged and later recovered in the upper Tanana River, and (c) number of chums tagged and later recovered in the Toklat River. The date of 50% run passage for each stock is indicated with dotted line.

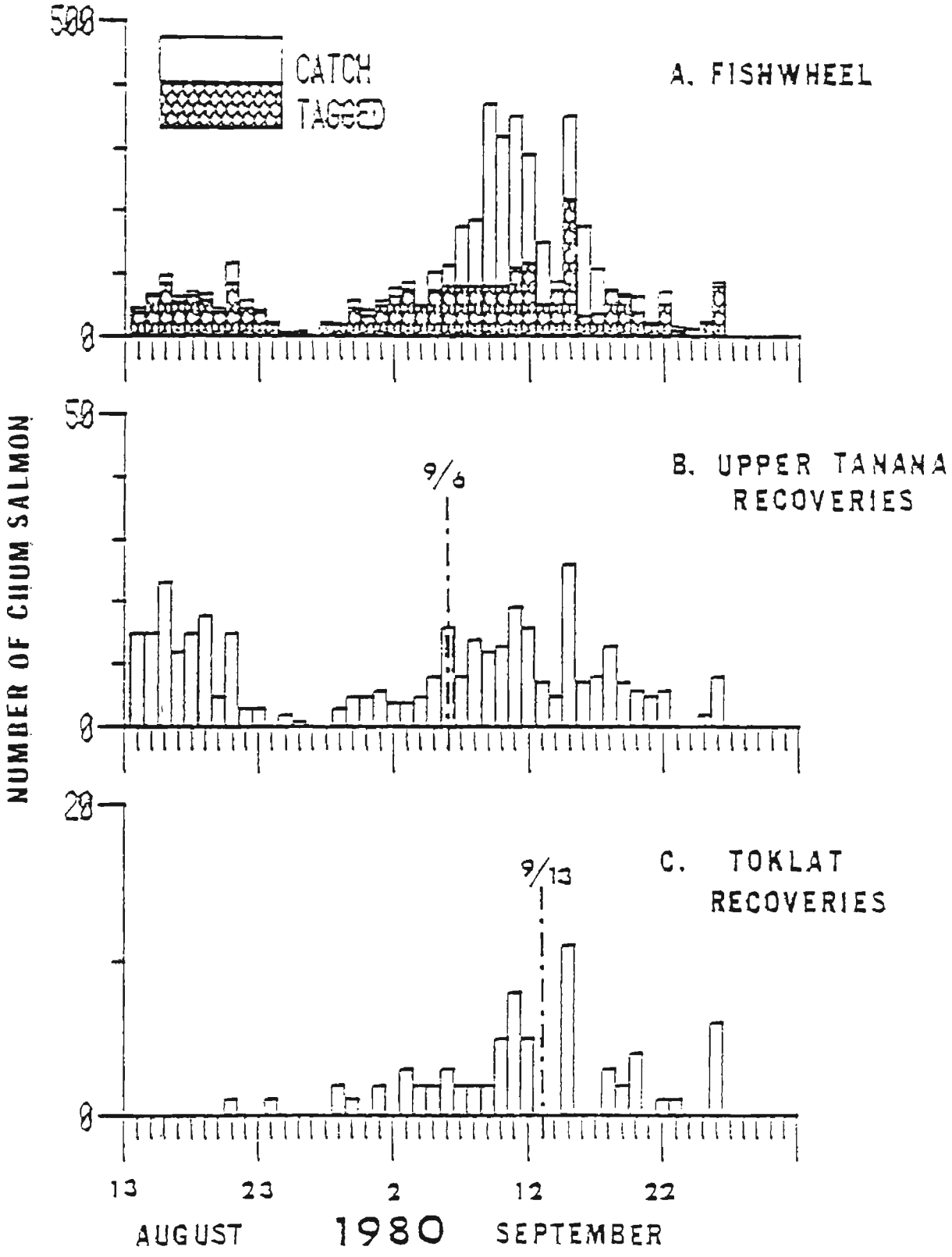

Figure 7. Run timing of fall chum salmon along the north bank of the Tanana River, 8 mi below Manley Hot Springs, in 1980, as demonstrated by (a) number of chums captured by fishwheel and tagged daily, (b) number of chums tagged and later recovered in the upper Tanana River, and (c) number of chums tagged and later recovered in the Toklat River. The date of 50% run passage for each stock is indicated with dotted line.

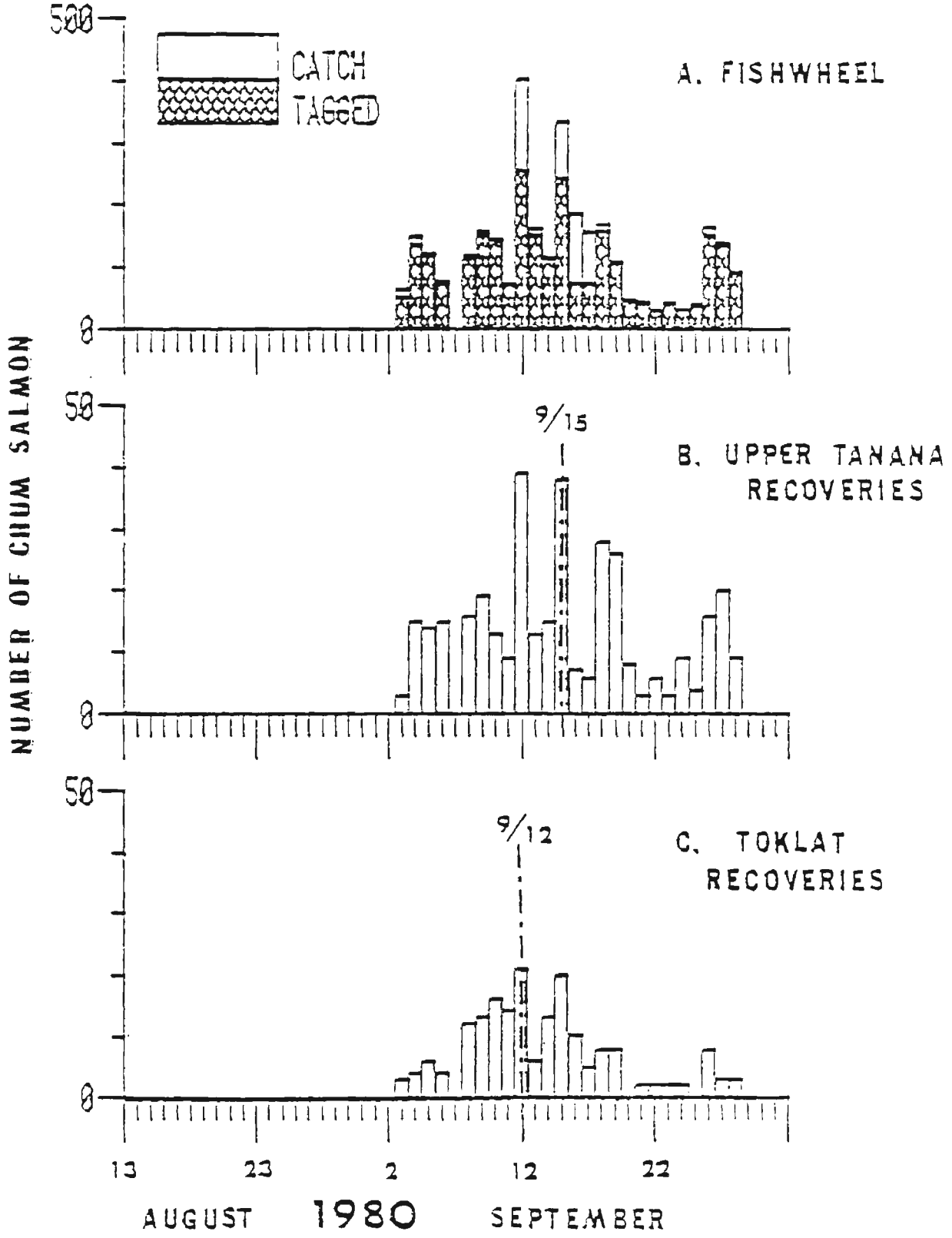

Figure 8. Run timing of fall chum salmon along the north bank of the Tanana River, 10 mi below Manley Hot Springs, in 1980, as demonstrated by (a) number of chums captured by fishwheel and tagged daily, (b) number of chums tagged and later recovered in the upper Tanana River, and (c) number of chums tagged and later recovered in the Toklat River. The date of 50% run passage for each stock is indicated with dotted line.

Table 14. Age, length, and sex ratio of live chum salmon sampled by fishwheel on the north bank of the Tanana River near Manley Hot Springs in August and September 1980, and of chum salmon carcasses sampled from the Toklat and Delta River spawning grounds in October and November 1980[1].

	Age 3_1			Age 4_1			Age 5_1			Total		
		Length			Length			Length			Length	
Tanana River	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Male	17 (6%)	545	22	123 (45%)	599	31	11 (4%)	626	39	151 (56%)	595	36
Female	6 (2%)	535	33	103 (38%)	574	26	12 (4%)	590	37	121 (44%)	574	29
Tanana River Totals	23 (8%)	542	25	226 (83%)	588	31	23 (8%)	607	42	272 (100%)	585	35
Toklat River												
Male	1 (2%)	556	-	19 (33%)	602	27	11 (19%)	601	30	31 (54%)	600	28
Female	1 (2%)	512	-	18 (32%)	575	21	7 (12%)	584	35	26 (46%)	575	28
Toklat River Totals	2 (4%)	534	31	37 (65%)	589	28	18 (32%)	594	32	57 (100%)	589	31
Delta River												
Male	5 (10%)	516	18	28 (57%)	592	28	1 (2%)	621	-	34 (69%)	582	38
Female	1 (2%)	543	-	14 (29%)	586	35	0 (-)	-	-	15 (31%)	583	35
Delta River Totals	6 (12%)	520	19	42 (86%)	590	30	1 (2%)	621	-	49 (100%)	582	37

[1] Age designated by Gilbert-Rich formula: total years of life in superscript, years of freshwater life in subscript. Tanana River fish measured from tip of snout to fork of tail in millimeters, and lengths later converted to standard mid-orbit to fork of tail measurement using conversion factors presented in Appendix Table 7. Toklat and Delta River fish were measured from mid-orbit to fork of tail. Numbers in parentheses are percent of each sample found in given age-sex group. Since many of the scales were resorbed or otherwise unreadable, these percentages may not reflect true age and sex ratios of the population.

age 3_1, 42 (86%) were age 4_1, and 1 (2%) was age 5_1 (Table 14). Sixty-nine percent of the sample was male, 31% female. Males were larger than females in the 4_1 age class, the only group with an adequate number of samples for a meaningful comparison (Table 14).

A total of 141 coho salmon was sampled for age and length from the north bank fishwheels and later proved to have readable scales. Fifty-two (37%) were age 3_2 and 89 (63%) were age 4_3 (Table 15). Seventy-one percent of the sample was male, 29% female. Females were larger than males in both age classes (Table 15). The relative proportion of age 3_2 and 4_3 coho salmon appears to vary geographically. Gilbert (1922) states that the proportion of age 4_3 coho salmon increases from south to north in North America, reaching a 60:40 ratio in the Yukon River. Drucker (1972) states that the age composition of coho salmon varies from predominantly 3_2 in California to predominantly 4_3 in Alaska. Pritchard (1940) reports that 98% of 6,312 coho salmon sampled from the commercial catch in British Columbia, Canada, between 1927 and 1930, were age 3_2. Gribanov (1962) found age 4_3 coho salmon to be predominant on the east coast of the Kamchatka Peninsula, U.S.S.R., while age 3_2 predominated on the west coast.

There was great difficulty in reading chum and coho salmon scales from the Tanana, Toklat, and Delta Rivers because of scale resorbtion and wear on the outer edge. This is not surprising considering the distance these fish have migrated in freshwater since entering the mouth of the Yukon River. Kim and Roberson (1968) had success in determining sockeye salmon ages in Bristol Bay by reading annual rings on the otoliths. This method might be used in conjunction with scale sampling in the upper Yukon River drainage to provide a more accurate method of determining chum and coho salmon ages.

Table 15. Age, length, and sex ratio of live coho salmon sampled by fish-wheel on the north bank of the Tanana River near Manley Hot Springs in September, 1980[1].

	Age 3_2			Age 4_3			Total		
		Length			Length			Length	
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Male	35 (25)	582	50	65 (46)	589	47	100 (71)	587	48
Female	17 (12)	608	21	24 (17)	599	38	41 (29)	603	32
Total	52 (37)	591	44	89 (63)	592	45	141 (100)	591	44

[1] Age designated by Gilbert-Rich formula: total years of life in superscript, years of freshwater life in subscript. Fish were measured from tip of snout to fork of tail, in millimeters. No length conversion factors are available. Numbers in parentheses are percent of total sample made up by the given age-sex group.

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APPENDICES

Appendix A. Method of adjusting daily sonar counts for midstream escapement and spawning salmon activity at the Anvik River sonar site, 1980.

Estimate of Midstream Passage

Since the sonar units count fish only 60 ft out from the west bank and 40 ft out from the east bank, chum salmon escapement through the middle portion of the river went undocumented. However, in 1978, clear water conditions allowed for visual counting of chum movement across the entire width of the river. The river was divided into five sectors of variable width from the west bank to the east bank and net upstream chum escapement was counted in 15-minute periods. The following results were obtained (Mauney 1980):

	River Sector (width)									
	1 (81')		2 (34')		3 (23')		4 (27')		5 (62')	
Date	N	%	N	%	N	%	N	%	N	%
7/15/78	550	63	-6	0	6	1	106	12	212	24
7/16/78	470	76	36	6	2	0	10	2	88	16
7/17/78	257	89	-5	0	10	3	-19	9	46	8
Total	1,277	72	25	1	18	1	97	6	346	20

These results indicate that 72% of the chum salmon escapement occurred in the 81 ft off the west bank, 8% in the middle 84 ft of the river, and 20% in the 62 ft off the east bank during a 3-day period in 1978. Since the 1980 sonar counters did not cover all of the west bank and east bank sectors created for this visual counting experiment, somewhat more than 8% of the daily escapement probably went uncounted. Therefore, the figure of 10% was used to adjust the sum of west and east bank sonar counts in 1980 to account for midstream escapement and arrive at a daily escapement estimate:

Date	Sonar Count Adjustment Formula
6/27 - 7/11/80	(west bank + east bank) x (1.10)

Estimate of Milling (Spawning) Fish

Beginning on 12 July 1980, spawning chum salmon began to affect sonar counts by milling over the sonar substrates and causing greater than one count per fish. It was not possible to accurately document the effect of this behavior on the east bank sonar substrate and the outer half of the west bank sonar substrate because of deep and turbid water conditions. However, it was possible to observe the fish over the inshore half of the west bank substrate and to develop adjustment factors. The corrected counts from the inshore

half of the west bank substrate had to then be expanded for the entire river. To do this, the data collected previous to the spawning salmon problem was examined to determine what percent of the total west bank counts occurred over the inshore half of the substrate, and then the relative contribution of the west bank sonar counts to total river escapement. This analysis is outlined below:

1980 Anvik Sonar - proportion of west bank sonar counts occurring over inshore half of substrate (sectors 1 to 6).

Date	Sectors 1 to 6	Sectors 7 to 12	Total	Total/1 to 6
6/30	11,269	2,504	13,773	1.222
7/01	15,450	6,123	21,573	1.396
7/02	8,342	10,772	19,114	2.291
7/03	8,632	1,391	10,023	1.161
7/04	5,543	1,514	7,057	1.273
7/05	11,028	1,339	12,367	1.121
7/06	11,495	2,656	14,151	1.231
7/07	5,981	1,715	7,696	1.287
7/08	11,555	2,534	14,089	1.219
7/09	12,503	1,572	14,075	1.126
7/10	18,822	7,296	26,118	1.388
7/11	17,471	5,796	23,267	1.332
Total	138,091	45,212	183,303	1.327

1980 Anvik Sonar - east bank sonar counts as a proportion of west bank sonar counts.

Date	East Bank	West Bank	East/West
6/30	2,162	13,773	0.157
7/01	1,831	21,573	0.085
7/02	998	19,114	0.052
7/03	793	10,023	0.079
7/04	1,220	7,057	0.173
7/05	2,269	12,367	0.183
7/06	1,130	14,151	0.080
7/07	2,192	7,696	0.285
7/08	3,256	14,089	0.231
7/09	2,690	14,075	0.191
7/10	2,955	26,118	0.113
7/11	3,938	23,267	0.169
Total	25,434	183,303	0.139

This provides a factor (1.327) to expand sonar counts from the inshore half of the west bank substrate to the entire west bank substrate, and a second factor (1.39) to expand for the east bank. Before these factors can be applied to sonar counts from the inshore half of the west bank substrate, these counts must be adjusted for multiple counting of spawning chum salmon. From 12 July through 25 July, visual counts were made of chum salmon over the inshore half of the west bank sonar substrate when water and light conditions permitted accurate observation. The substrate was moved out into deeper water twice during this period, so the data is grouped for each substrate position as follows:

Date	Time	Chum Salmon Counts		Visual/Sonar
		Visual (net upstream)	Sonar	
7/15	1400-1500	193	100	1.930
7/15	1530-1600	55	175	0.314
7/16	1100-1200	64	413	0.155
7/16	1700-1800	592	331	1.786
7/17	0910-0940	37	192	0.193
Total	4 hours	941	1,211	0.77
7/18	0900-1000	737	580	1.271
7/18	1000-1100	644	471	1.367
7/18	1100-1115	125	102	1.225
7/18	1130-1200	237	133	1.782
7/18	1200-1215	149	179	0.832
7/18	1230-1300	209	335	0.624
7/18	1300-1400	666	796	0.837
7/18	1700-1800	527	532	0.991
7/19	1100-1200	182	210	0.867
7/21	1300-1400	50	48	1.042
7/22	1300-1400	78	79	0.987
7/22	1900-1930	0	7	0
Total	9 hours	3,604	3,472	1.038
7/23	1300-1330	18	20	0.900
7/23	1900-1930	3	90	0.033
7/25	1400-1500	20	153	0.131
7/25	1705-1735	2	20	0.100
Total	2.5 hours	43	283	0.152

Sonar count adjustment formulas from 12 July to 25 July, the period of chum salmon milling, will take the general form:

$$\left[\left(\begin{array}{c}\text{West Bank}\\ \text{Sector 1 to 6}\end{array}\right) \times \left(\begin{array}{c}\text{Adjustment Factor}\\ \text{for Spawner Over-}\\ \text{count}\end{array}\right)\right] \times \left(\begin{array}{c}\text{Expansion Factor}\\ \text{for entire substrate}\end{array}\right) \times \left(\begin{array}{c}\text{Expansion Factor}\\ \text{for entire river,}\\ \text{including mid-}\\ \text{stream and east}\\ \text{bank}\end{array}\right)$$

The specific formulas are listed below:

Date	Sonar Count Adjustment Formula
7/12 - 7/17/80	[(West 1 to 6) (0.777)] (1.327)(1.24)
7/18 - 7/22/80	[(West 1 to 6)] (1.327)(1.24)
7/23 - 7/25/80	[(West 1 to 6)] (0.152)] (1.327)(1.24)

It should be noted that the spawner correction factor for the period 7/18-7/22/80 was very nearly 1, therefore, it drops out of the equation.

Appendix Table 1. Age and sex composition of chum salmon carcasses sampled from the Anvik River, 1972-1980[1].

	Age 3_1			Age 4_1			Age 5_1			Age 6_1			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1972	0(-)	0(-)	0(-)	25(8)	37(12)	62(19)	138(43)	115(36)	253(79)	4(1)	1(-)	5(2)	167(52)	153(48)	320(100)
1973	11(1)	37(5)	48(6)	204(26)	401(51)	605(77)	49(6)	79(10)	128(16)	1(-)	1(-)	2(-)	265(34)	518(66)	783(100)
1974	12(3)	24(6)	36(9)	197(49)	120(30)	317(79)	34(8)	12(3)	46(11)	2(-)	1(-)	3(1)	245(61)	157(39)	402(100)
1975	4(1)	17(3)	21(4)	253(43)	288(49)	541(83)	13(2)	9(2)	22(4)	0(-)	0(-)	0(-)	270(46)	314(54)	584(100)
1976	5(1)	4(1)	9(2)	43(7)	35(6)	78(13)	233(39)	281(47)	514(86)	0(-)	0(-)	0(-)	281(47)	320(53)	601(100)
1977	20(3)	111(19)	131(22)	161(27)	270(46)	431(73)	7(1)	15(2)	22(4)	3(1)	2(-)	5(1)	191(32)	398(68)	589(100)
1978	0(-)	1(-)	1(-)	210(38)	180(33)	390(71)	79(14)	82(15)	161(29)	0(-)	0(-)	0(-)	289(52)	263(48)	552(100)
1979	2(-)	12(2)	14(2)	154(27)	193(33)	347(60)	115(20)	99(17)	214(37)	2(-)	2(-)	4(1)	273(47)	306(53)	579(100)
1980	0(-)	1(-)	1(-)	147(35)	226(53)	373(88)	20(5)	31(7)	51(12)	0(-)	0(-)	0(-)	167(39)	258(61)	425(100)
Total	54(1)	207(4)	261(5)	1,394(29)	1,750(36)	3,144(65)	688(14)	723(15)	1,411(29)	12(-)	7(-)	19(-)	2,148(44)	2,687(56)	4,835(100)

[1] Ages designated by Gilbert-Rich formula: Total years of life in superscript, years of freshwater life in subscript. Numbers in parentheses are percent of total sample made up by the given age-sex group.

Appendix Table 2. Age and sex composition of king salmon carcasses sampled from the Anvik River, 1972-1980[1].

	Age 4_2			Age 5_2			Age 6_2			Age 7_2			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1972	0(-)	0(-)	0(-)	8(53)	0(-)	8(53)	2(13)	5(33)	7(47)	0(-)	0(-)	0(-)	10(67)	5(33)	15(100)
1973	1(10)	0(-)	1(10)	0(-)	0(-)	0(-)	5(50)	3(30)	8(80)	0(-)	1(10)	1(10)	6(60)	4(40)	10(100)
1974[2]															
1975	1(12)	0(-)	1(12)	4(50)	1(12)	5(62)	1(12)	1(12)	2(25)	0(-)	0(-)	0(-)	6(75)	2(25)	8(100)
1976	6(13)	0(-)	6(13)	25(56)	5(11)	30(67)	2(4)	7(16)	9(20)	0(-)	0(-)	0(-)	33(73)	12(27)	45(100)
1977	2(2)	1(1)	3(3)	27(23)	6(5)	33(28)	27(23)	48(41)	75(64)	2(2)	4(3)	6(5)	58(50)	59(50)	117(100)
1978	13(17)	0(-)	13(17)	10(13)	1(1)	11(14)	13(17)	39(51)	52(68)	0(-)	1(1)	1(1)	36(47)	41(53)	77(100)
1979	17(37)	0(-)	17(37)	14(30)	0(-)	14(30)	6(13)	6(13)	12(26)	0(-)	3(7)	3(7)	37(80)	9(20)	46(100)
1980	19(23)	1(1)	20(24)	21(25)	22(26)	43(51)	1(1)	16(19)	17(20)	0(-)	3(4)	3(4)	41(49)	42(51)	83(100)
Total	59(15)	2(-)	61(15)	109(27)	35(9)	144(36)	57(14)	125(31)	182(45)	2(-)	12(3)	14(3)	227(57)	174(43)	401(100)

[1] Ages designated by Gilbert-Rich formula: Total years of life in superscript, years of freshwater life in subscript. Numbers in parentheses are percent of total sample made up by the given age-sex group.

[2] No samples were collected in 1974.

Appendix Table 3. Daily chum salmon catch by fishwheel on the Tanana River near Manley Hot Springs, 1980.

Date	North Bank[1]		South Bank[2]		North Bank #2[3]	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
8/11	-	-	6	6	-	-
8/12	-	-	4	10	-	-
8/13	-	-	24	34	-	-
8/14	47	47	48	82	-	-
8/15	69	116	20	102	-	-
8/16	99	215	10	112	-	-
8/17	65	280	24	136	-	-
8/18	73	353	25	161	-	-
8/19	67	420	0	161	-	-
8/20	46	466	1[4]	162	-	-
8/21	116	582	0[4]	162	-	-
8/22	58	640	5	167	-	-
8/23	43	683	3	170	-	-
8/24	22	705	2	172	-	-
8/25	8[4]	713	0	172	-	-
8/26	11	724	0	172	-	-
8/27	3	727	0	172	-	-
8/28	23	750	0	172	-	-
8/29	21	771	0[4]	172	-	-
8/30	60	831	-	-	-	-
8/31	41	872	-	-	-	-
9/01	57	929	-	-	-	-
9/02	78	1,007	-	-	-	-
9/03	87[4]	1,094	-	-	66	66
9/04	52[4]	1,146	-	-	150	216
9/05	104	1,250	-	-	124	340
9/06	114	1,364	-	-	78[4]	418
9/07	175	1,540	-	-	0[4]	418
9/08	184	1,724	-	-	120	538
9/09	369	2,093	-	-	158	696
9/10	317	2,410	-	-	145[4]	841
9/11	351	2,761	-	-	74[4]	915
9/12	289	3,050	-	-	402	1,317
9/13	148	3,198	-	-	161	1,478
9/14	88[4]	3,286	-	-	117	1,595
9/15	351	3,637	-	-	335	1,930
9/16	176	3,813	-	-	184	2,114
9/17	108[4]	3,921	-	-	157	2,271
9/18	74[4]	3,995	-	-	170	2,441
9/19	67[4]	4,062	-	-	112[4]	2,553
9/20	66[4]	4,128	-	-	49[4]	2,602
9/21	22[4]	4,150	-	-	46[4]	2,648
9/22	71[4]	4,221	-	-	33[4]	2,681
9/23	16[4]	4,237	-	-	44	2,725
9/24	14[4]	4,251	-	-	34	2,759
9/25	26	4,277	-	-	41	2,800
9/26	88	4,365	-	-	167	2,967
9/27	-	-	-	-	141	3,108
9/28	-	-	-	-	95	3,203

[1] Fishwheel located 8 mi below the Manley boat landing.

[2] Fishwheel located at several sites between 1/2 mile above and miles below Manley boat landing. Low catches and unfavorable water current and depth resulted in fishwheel being moved to North Bank of the river.

Appendix Table 3. Daily chum salmon catch by fishwheel on the Tanana River near Manley Hot Springs, 1980 (continued).

[3] Fishwheel located 10 mi below the Manley boat landing.

[4] Fishwheel effectively fishing only part of the day.

Appendix Table 4. Chum salmon tagged by fishwheel on the Tanana River near Manley Hot Springs, 1980.

Date	North Bank #1		South Bank		North Bank #2	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
8/11	-	-	5	5	-	-
8/12	-	-	4	9	-	-
8/13	-	-	24	33	-	-
8/14	39	39	48	81	-	-
8/15	64	103	20	101	-	-
8/16	83	186	10	111	-	-
8/17	54	240	23	134	-	-
8/18	66	306	22	156	-	-
8/19	58	364	0	156	-	-
8/20	40	404	1	157	-	-
8/21	86	490	0	157	-	-
8/22	47	537	4	161	-	-
8/23	38	575	3	164	-	-
8/24	18	593	2	166	-	-
8/25	6	599	0	166	-	-
8/26	10	609	0	166	-	-
8/27	3	612	0	166	-	-
8/28	20	632	0	166	-	-
8/29	20	652	0	166	-	-
8/30	44	696	-	-	-	-
8/31	33	729	-	-	-	-
9/01	50	779	-	-	-	-
9/02	66	845	-	-	-	-
9/03	75	920	-	-	52	52
9/04	48	968	-	-	136	188
9/05	75	1,043	-	-	119	307
9/06	81	1,124	-	-	74	381
9/07	81	1,205	-	-	0	381
9/08	80	1,285	-	-	114	495
9/09	80	1,365	-	-	151	646
9/10	81	1,446	-	-	142	788
9/11	111	1,557	-	-	72	860
9/12	118	1,675	-	-	257	1,117
9/13	52	1,727	-	-	154	1,271
9/14	76	1,803	-	-	115	1,386
9/15	217	2,020	-	-	244	1,630
9/16	34	2,054	-	-	75	1,705
9/17	35	2,089	-	-	75	1,780
9/18	74	2,163	-	-	159	1,939
9/19	64	2,227	-	-	107	2,046
9/20	39	2,266	-	-	46	2,092
9/21	21	2,287	-	-	42	2,134
9/22	52	2,339	-	-	30	2,164
9/23	10	2,349	-	-	43	2,207
9/24	0	2,349	-	-	34	2,241
9/25	23	2,372	-	-	38	2,279
9/26	81	2,453	-	-	154	2,433
9/27	-	-	-	-	137	2,570
9/28	-	-	-	-	90	2,660

Appendix Table 5. Daily coho salmon catch by fishwheel on the Tanana River near Manley Hot Springs, 1980.

Date	North Bank #1		North Bank #2	
	Daily	Cumulative	Daily	Cumulative
8/29	1	1	-	-
8/30	0	1	-	-
8/31	0	1	-	-
9/01	0	1	-	-
9/02	1	2	-	-
9/03	1[1]	3	1	1
9/04	0[1]	3	2	3
9/05	3	5	0	3
9/06	8	14	3[1]	6
9/07	11	25	0[1]	6
9/08	6	31	6	12
9/09	13	44	3	15
9/10	15	59	5[1]	20
9/11	19	78	0[1]	20
9/12	20	98	6	26
9/13	11	109	5	31
9/14	4[1]	113	7	38
9/15	13	126	12	50
9/16	9	135	9	59
9/17	10[1]	145	9	68
9/18	5[1]	150	21	89
9/19	5[1]	155	16[1]	105
9/20	28[1]	183	5[1]	110
9/21	14	197	7[1]	117
9/22	24[1]	221	6[1]	123
9/23	29[1]	250	24	147
9/24	25[1]	275	28	175
9/25	33	308	36	211
9/26	104	412	37	248
9/27	-	-	57	305
9/28	-	-	36	341

[1] Fishwheel effectively fishing only part of the day.

Appendix Table 6. Coho salmon tagged by fishwheel on the Tanana River near Manley Hot Springs, 1980.

Date	North Bank #1		North Bank #2	
	Daily	Cumulative	Daily	Cumulative
9/02	1	1	-	-
9/03	1	2	-	-
9/04	0	2	2	2
9/05	2	4	0	2
9/06	8	12	3	5
9/07	10	22	0	5
9/08	6	28	6	11
9/09	12	40	3	14
9/10	15	55	5	19
9/11	19	74	0	19
9/12	20	94	6	25
9/13	11	105	5	30
9/14	4	109	7	37
9/15	12	121	9	46
9/16	5	126	5	51
9/17	10	136	11	62
9/18	5	141	25	87
9/19	5	146	16	103
9/20	26	172	5	108
9/21	14	186	6	114
9/22	25	211	6	120
9/23	21	232	24	144
9/24	0	232	28	172
9/25	33	265	36	208
9/26	101	366	35	243
9/27	-	-	54	297
9/28	-	-	36	333

Appendix Table 7. Conversion factors for Yukon River fall chum salmon length measurements.

Fall chum salmon were captured by fishwheel along the north and south bank of the Yukon River at Galena, and on the south bank at Ruby in August and September, 1977. Two length measurements were taken on each fish: from tip of snout to fork of tail, and from mid-orbit to fork of tail, in millimeters. The data is summarized below:

Location	N	ΣX	$\bar{X}$
Male Snout to Fork of Tail			
Galena North	68	46,143	678
Galena South	98	66,642	680
Ruby	113	77,374	685
TOTAL	279	190,159	682
Male Mid-eye to Fork of Tail			
Galena North	60	37,121	618
Galena South	98	60,026	613
Ruby	112	68,365	610
TOTAL	270	165,512	613
Female Snout to Fork of Tail			
Galena North	23	14,999	652
Galena South	159	105,945	667
Ruby	116	73,586	634
TOTAL	298	194,580	653
Female Mid-eye to Fork of Tail			
Galena North	34	20,812	612
Galena South	159	96,344	606
Ruby	87	51,208	589
TOTAL	280	168,364	601

Male Conversion = 613/682 = 0.899

Female Conversion = 601/653 = 0.920